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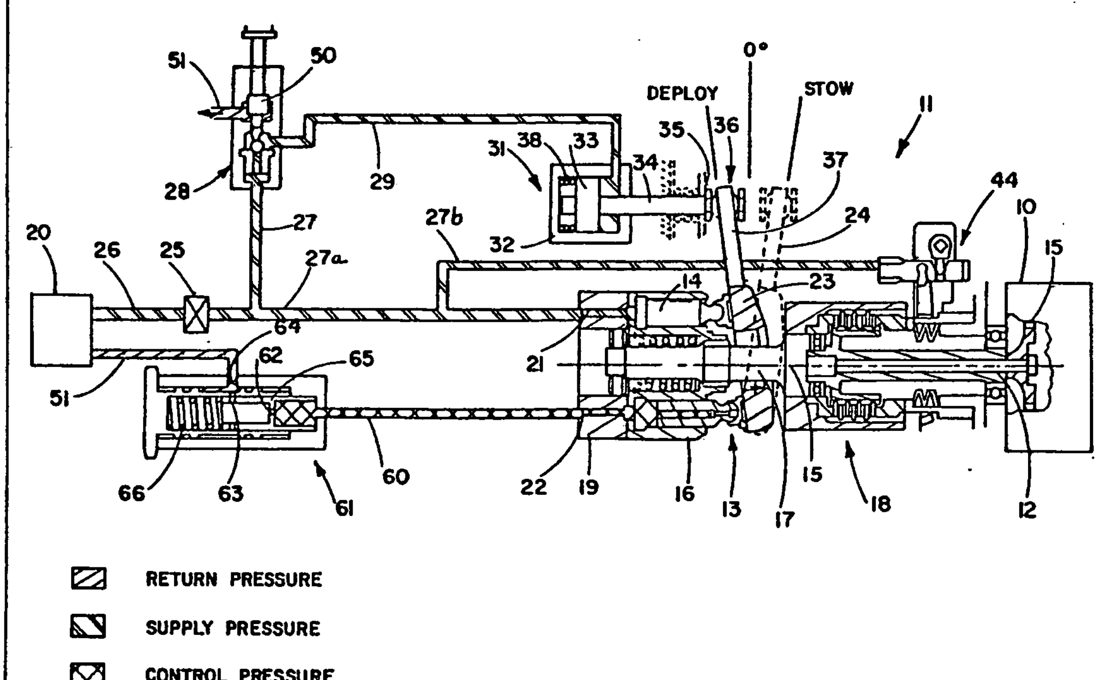
(54) Drive units

(57) A drive unit 11 is suitable for operating a thrust reverser 10 of an aircraft engine. A rotary hydraulic motor 13 has a number of pistons 14 and is controlled by a wobbler 23. The wobbler 23 is connected to a control arm 37 and moved through a ball joint 36 by a piston 33. The piston 33 is subject to the pressure of a spring 38 for moving the wobbler 23 to a stow position 24 at a low rate, and to hydraulic pressure from a solenoid-operated valve 28 for moving to a deploy position at a high rate. A brake 18 is applicable to an output shaft 17 of the motor 13. A valve 61 regulates the return flow from the motor 13 for controlling the motor speed.



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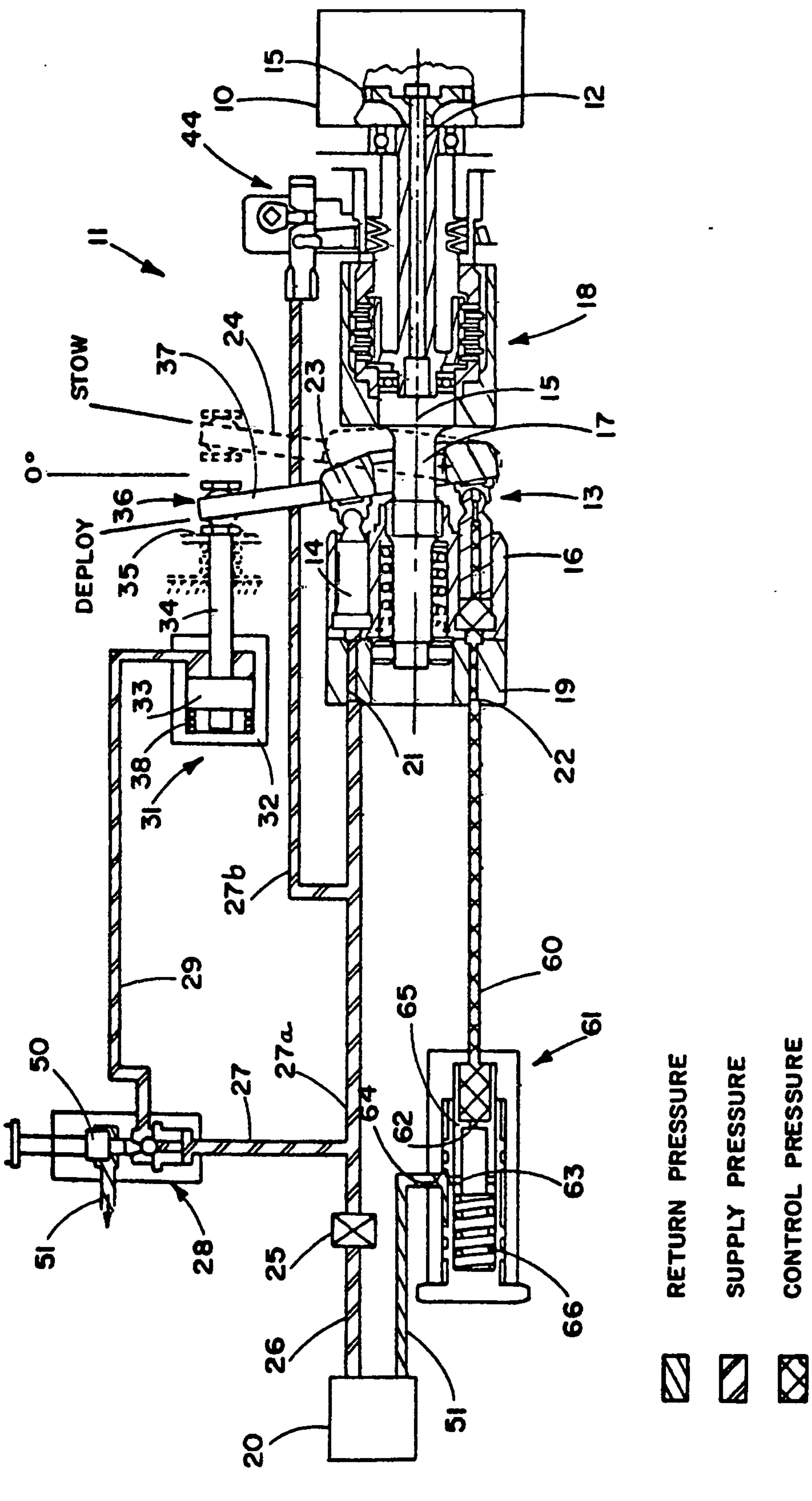
STOW
0°
DEPLOY
RETURN PRESSURE
SUPPLY PRESSURE
CONTROL PRESSURE

SPECIFICATION

Drive units

The invention relates to drive units suitable for operating the thrust reversers of aircraft engines. Such units are the subject of our earlier Patent Specifications GB 2 019 951 and 2 020 065.

The invention provides a drive unit comprising a hydraulic wobbler-controlled multi-piston rotary motor and means for moving the wobbler from a neutral position at a low rate to a first position with motor rotation in one sense and at a high rate to a second position with motor rotation in the opposite sense.

The said means preferably comprises a piston subject to spring pressure for moving the wobbler to the first position and subject to hydraulic pressure for moving the wobbler to the second position. The unit preferably includes a solenoid-operated valve for controlling the flow of hydraulic fluid to the piston.

Means for regulating the return flow from the motor for controlling the motor speed are preferably included, as is a brake applicable to a motor output shaft, the brake being releasable by hydraulic pressure supplied to the motor.

By having two different rates of movement, the power demanded by the unit is reduced. By moving the wobbler between the two positions there is no need for the flow of fluid to the motor to be interrupted, and hydraulic losses and stress on the motor are reduced.

Drawings

The single Figure is a schematic of a drive unit according to the invention with certain components shown in central vertical section.

In the drawing, a power drive unit, generally at 11, is coupled to a thrust reverser mechanism 10 (details not shown) by a rotatable shaft 12. The rotatable shaft 12 is rotated in either of two directions by a two displacement, variable, bi-directional, wobbler controlled hydraulic motor, indicated generally at 13, and which in the form shown, is an axial piston motor. As is well known in the art, an axial piston motor has a series of pistons 14 carried within a series of longitudinal bores in a cylinder block 16 which connects to an output shaft 17. A brake 18 of conventional design is shown interposed between the output shaft 17, the rotatable shaft 12 and the thrust reverser mechanism 10. The brake 18 is a pressure release brake which grounds the output shaft 17 and the rotatable shaft 12 whenever the supply lines 27*b*, 27*a* and 26 are depressurized. A manual brake release is also provided and is generally indicated at 44. The rotatable shaft 12 has a gear 15 which meshes with gearing not shown in the thrust reverser mechanism 10. A valve block 19, forming part of the motor, has a supply port 21 for directing fluid under pressure to the motor 13.

The displacement of the motor may be varied by varying the stroke of the pistons 14. This is accomplished by positioning of a wobbler 23 which may be set at various angles. In the illustration, the wobbler 23, shown in full line in what is termed the "deploy" position, while the broken line position 24 is termed the "stow" position. Between the deploy and stow position there is indicated a 0°, neutral or center position. Those familiar with this type of hydraulic motor will recognize that movement of the wobbler 23 through the neutral position will result in the reversal of the output shaft 17, given of course the maintenance of supply pressure at supply port 21 and return pressure at return port 22.

It will be recalled that of the known actuation systems, the hydraulic power consumed is dictated by that of the load and rate that the system will operate and that heretofore such actuation systems by their design operate at maximum load and maximum rate. This type of operation significantly increases the power demand of the systems. The invention being described herein reduces the power demanded by the system by providing different displacements of the hydraulic motor for the deploy and stow cycles of the motor. The deploy and stow cycles corresponding respectively to a low displacement, high rate of operation, and a high displacement, low rate of operation.

The torque required from the hydraulic motor in the deploy cycle is less than that required in the stow direction, however, the time required to deploy is much less than the time required to stow. Therefore, if a fixed displacement were used, the torque would have to be sized on the stow loads, while the motor speed utilized to calculate maximum flow would have to be based on the deploy cycle. This would result in an inordinately high flow during deploy, and a faster than desired stow time, thereby penalizing the aircraft hydraulic system. The use of the two displacement motor of the invention allows the motor to be tailored for the deploy cycle at minimum torque levels and high r.p.m. or rate, and for the stow cycle at high torque levels and lower r.p.m.'s or rate.

Movement of the wobbler 23 is controlled via wobbler control arm 37 which is integrally secured to the wobbler at one end and mechanically coupled via a ball joint 36 to a piston rod 34. The piston rod 34 has secured for movement therewith a piston 33 which is mounted for sliding movement in the valve housing 32 of a wobbler control piston unit 31. Movement of the piston 33 is controlled as a function of the fluid pressure experienced by the right face of piston 33 and the force exerted by helical spring 38. The wobbler control piston unit 31 is hydraulically coupled through a deploy solenoid valve 28 to a fluid supply means in the form of line 26 via branch supply lines 29, 27 and 27*a*. A filter screen 25 is shown schematically in supply line 26. A fluid return means takes the form of return line 51.

Reversal of direction of the hydraulic motor 13 occurs in a smooth manner since pressure loading the hydraulic pistons 14 does not change from one side of the valve block to the opposite side for

reversing directions, but remains on the pistons 14, while the wobbler 23 changes angle between the deploy and stow positions. Changing the angle from the neutral position in either direction results in a direction of torque change only, and not a direction of axial force change on the pistons, as where a directional control valve would in the prior art. This change in torque is smooth and lowers the stress levels on all the motor parts during the directional reversal which could occur with a mid-stroke reversal dynamically on the thrust reverser.

Since the pressure never changes ports on the hydraulic motor 13, no pressure spikes associated with valve openings and closing will be seen by either the thrust reverser hydraulic equipment or the aircraft hydraulic system when the motor 13 is signaled to change direction.

The deploy solenoid valve 28 is a single-stage valve spring type which is pressure loaded to the closed or stow direction. Energization of the solenoid 50 allows pressure from supply line 26 to be delivered to the wobbler control piston unit 31. An isolation valve 20 is shown in block form connected across supply line 26 and return line 51. The isolation valve is conventional and consists of a solenoid driven pilot stage and a spool valve second stage. The wobbler control piston is biased by helical spring 38 to stow.

Note also that the wobbler 23 and its wobbler control arm 37 are mounted for pivotal movement about a locus of points which fall below the centerline 15 of motor output shaft 17. The pivotal arrangement tends to cause the wobbler 23 to be hydromechanically biased towards the stow position as a consequence of the fluid pressure inherently present on the pistons 14. The aforementioned energization of the solenoid 50 allows supply pressure to be transmitted through the solenoid deploy valve 28 to the piston 33 which acts against the spring 38 to position the wobbler 23 through piston rod 34, ball joint 36, and wobbler control arm to the deploy stop 35, shown in dotted outline.

A discharge flow regulating valve 61 is interposed between the return lines 51 and 60. The discharge flow regulating valve 61 controls the speed of the motor 13 and is of conventional structure, with fluid entering from line 60 and flowing through an orifice 62 in a cup-shaped valve member 65. The valve member 65 has ports 63 communicating with fixed casing ports 64 which communicate with the return line 51. The orifice 62 creates a pressure drop there across, and when a certain flow rate is exceeded, the differential pressure is sufficient to shift the valve member 65 to the left and compress the spring 66 whereby ports 63, 64 restrict outlet flow. As a result, the maximum flow rate through the return line 51, 60 is controlled.

The operation of the just described actuation system will now be described. The actuation system contemplates that in order to enter the deploy cycle for the thrust reverser mechanism 10, an electrical signal is delivered to the solenoid 50 of the deploy solenoid pilot valve 28 via electrical leads not shown. Energization of the solenoid 50 allows supply fluid under pressure from supply line 26 to be delivered to the right hand side of the piston 33 of the wobbler control piston unit 31 via lines 27 and 29. The supply pressure on the right hand side face of piston 33 causes the piston 33 to move to the left, which causes the wobbler 23 and its wobbler control arm 37 to move to a 10° angle, the deploy position which is illustrated. In an actual embodiment of the invention, this amounts to a motor displacement of 0.178 in^3/rev. In the commercial environment in which the invention has been designed to operate, this displacement has been determined to be optimum for the power required in the deploy phase. With the wobbler 23 in the deploy position, the motor 13 accelerates to the design speed of 9400 r.p.m.s, driving the output shafts 17 and 12 to the thrust reverser mechanism. In an actual embodiment, the 90% deploy position is reached in less than 1.75 seconds and the system continues to run at this rate until stops (not shown) are contacted, and the motor 13 is stalled. No feedback or rigging of the actuation system is required with this design approach due to the low rotating inertia of the two displacement hydraulic motor concept of the invention.

To stow the thrust reverser system, the aforementioned electrical signal to the solenoid 50 of the deploy solenoid valve 28 is simply removed, allowing the spring 38 which biases the wobbler control piston 33 to throw the wobbler 23 via rod 34, balljoint 36, and wobbler control arm 37 to a +14° angle or 0.25 in^3/rev displacement of the motor 13. A higher displacement is required to stow the thrust reverser against an opposing load that is typically 30% greater than the opposing deploy load. This difference between the opposing stow and deploy loads explains the need for a higher displacement requirement for the motor during the stow cycle.

Directional reversal is accomplished very smoothly as the motor wobbler 23 switches displacement angle over 0° with the motor ports 21, 22 pressurized. The motor output follows a near perfect sine wave as the fluid coupling within the motor 13 reverses direction, and the motor accelerates to 6,700 r.p.m.s to stow the reverser to 90% in 2.69 seconds. As in the deploy cycle, the remaining 10% of stroke is accomplished at the same approximate speed as the first 90%, but in the stow direction the actuators do not bottom on stops, but instead drive the thrust reverser structures together against a deformable seal. The actuators, thrust reverser structure and deformable seal are conventional and are not shown.

The aforementioned seal maintains the aerodynamic efficiency of the fan cowl during forward thrust, and provides the means for a residual load in the actuation system that prevents fretting during the vibrations of flight. This residual load is held into the system by the brake 18 which is applied as the isolation valve 20 is closed.

Pre-torquing of the various shafts of the actuation system, when the system is installed, is not necessary as it has been in some prior art designs since the aircraft hydraulic system can provide this function after the first operational cycle of the system during check-out by driving the motor into the stops and applying the brake to hold the torque. The manual release brake 44 is provided on the power drive unit 11 to release this residual torque so that the various shafts of the actuation system can be removed if service is required.

The speed is controlled by the discharge flow regulating valve 61 in the manner described hereinbefore. The different deploy and stow speeds are a result of two different motor displacements, and the resulting torque/speed characteristics of the motor, not different, flow in each direction.

CLAIMS

1. A drive unit comprising a hydraulic wobbler-controlled multi-piston rotary motor and means for moving the wobbler from a neutral position at a low rate to a first position with motor rotation in one sense and at a high rate to a second position with motor rotation in the opposite sense.

2. A unit according to claim 1 in which the said means comprises a piston subject to spring pressure for moving the wobbler to the first position and subject to hydraulic pressure for moving the wobbler to the second position.

3. A unit according to claim 2 including a solenoid-operated valve for controlling the flow of hydraulic fluid to the piston.

4. A unit according to any preceding claim including means for regulating the return flow from the motor for controlling the motor speed.

5. A unit according to any preceding claim including a brake applicable to a motor output shaft.

6. A unit according to claim 5 in which the brake is releasable by hydraulic pressure supplied to the motor.

7. A drive unit as herein described with reference to the drawing.

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